

## DARWINULOCOPINA (CRUSTACEA: PODOCOPA), A NEW SUBORDER PROPOSED FOR NONMARINE PALEOZOIC TO HOLOCENE OSTRACODA

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*Abstract.*—The new suborder Darwinulocopina is proposed in the order Podocopida Sars, 1865, superorder Podocopa Kesling, 1981 to include living and fossil ostracode genera. The new category is coordinate with the Cypridocopina Kozur, 1972 and the Cytherocopina Gründel, 1967. Diagnostic characters of the Darwinulocopina are a posterior process instead of furcae and furcal attachments, and a rosette adductor muscle attachment scar comprised of large stigmata. The geologic range of the Darwinulocopina is Paleozoic to Holocene.

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The superfamily Darwinulacea Brady & Norman, 1889, contained, until after 1961, only one family, the Darwinulidae Brady & Norman, 1889, which in turn consisted of one genus: *Darwinula*, based on the type species *Darwinula stevensoni*, (Brady & Robertson 1870) (Swain 1961:Q253). Until 1972, the Darwinulacea Brady & Norman, 1889 have been classified in the suborder Podocopina Scott, 1961:Q86-Q88, in the order Podocopida Sars, 1865. Gründel (1967:324) discussed the classification of the Podocopida in the Treatise (Moore 1961), in which he included 3 suborders: Metacopina Sylvester-Bradley, 1961:358 (type genus *Quasillites* Coryell & Malkin, 1936, p. 18); Bairdiocopina new suborder (type genus *Bairdia* McCoy, 1844:164); and the Cytherocopina new suborder (type genus *Cythere* O. F. Müller, 1785, p. 49). The suborder Bairdiocopina Gründel, 1967, included the Bairdiacea Sars, 1885. Cypridacea Baird, 1845, and the ?Darwinulacea.

Kozur (1972:13-15) referred the Darwinulacea to his emended suborder Cypridocopina Jones, 1901 [*Nom. transl. ex* Cypridida Jones in Chapman, 1901:147, 154]. Kozur considered the suborder Metacopina Sylvester-Bradley, 1961, to be a junior synonym of the Cypridocopina (1972:13), to

which he referred both the Darwinulacea and the Metacopina, and suggested that *Darwinula* Brady & Norman, 1889, developed from *Carbonita* because "The stem group [of *Darwinula*] is probably the genus *Carbonita*, that has hitherto been referred to the Cypridacea. According to Pollard (1966) *Carbonita claripunctata* has sometimes a rosette-like arrangement of the adductor muscle scars (similar to *Darwinula*). *Carbonita* is also very similar in outline to *Darwinula*, also in that the right valve is larger than the left in this genus. Therefore *Carbonita* should be referred to the Darwinulacea." [my translation]. Kesling (1981) also referred the Darwinulacea to the Cypridocopina, but recognized the Metacopina as an order in the superorder Podocopa. Kesling's (1981, p. 291, 300, 308) recommended classification of the Podocopida Sars, 1865, the superorder Podocopa is followed herein.

The Darwinulacea should be excluded from the Cypridocopina based on both shell morphology and soft parts; consequently, the new suborder Darwinulocopina (type genus *Darwinula* Brady & Robertson, in Jones 1885:346), is proposed for the living and fossil taxa that have been referred to the Darwinulacea (Sohn 1987:151).

### Superorder Podocopa Sars, 1865

Kesling (1981:291) elevated the orders in Moore (1961) to superorder categories, and included the orders Podocopida Sars, 1865, p. 10, and the Metacopida Sylvester-Bradley, 1961, p. Q358 in the Podocopa.

#### Order Podocopida Sars, 1865

Kesling (1981:291) included in this order the suborders Bairdiocopina Gründel, 1967, Cypridocopina Jones (emend. Kozur, 1972) to include the superfamilies Cypridacea Baird, 1845, and Darwinulacea Brady & Norman, 1889, and the Cytherocopina Gründel, 1967. He described the Podocopida as follows: "Duplicature present except perhaps in earliest forms, typically large anteriorly and posteriorly and there set off from outer lamella by a vestibule. Contact groove not well developed if at all, at most a simple depression in inner lamella [infold]." (Kesling 1981:300).

The new suborder Darwinulocopina is proposed for the Darwinulacea to remove them from the Cypridocopina. The new suborder is coordinate with both the Cypridocopina and the Cytherocopina. The distinguishing characters among the Darwinulocopina, the Cypridocopina, and the Cytherocopina are listed in Table 1.

#### Darwinulocopina, new suborder

*Diagnosis.*—Small, smooth, elongate Podocopida; without any nodes, ridges, sulci; with very narrow normal and radial pore canals, without calcified inner lamella on infold. Hinge simple, overlap variable; outline of the adductor muscle-attachments scars (AMAS) pattern circular, consists of large individual scars (stigmata sensu Gramm 1982:201). Appendages of the type genus consist of pediform antennules and antennas; first thoracopod with respiratory plate; second and third thoracopods pediform: with posterior process; furcae lacking.

*Discussion.*—Howe, Kesling, & Scott

(1961: Q112-Q14) described "furca" as follows: "Furcae (furcal rami of some authors) are appendage-like structures attached to the posterior end of the body . . . . In the Podocopina the furcae are extremely variable . . . . In the Darwinulidae (fig. 8a) they are lacking or represented by a reflex process at the end of the thorax . . ."

Rome (1969) described and illustrated the furcal attachments in different subfamilies in the Cypridae Baird, 1845. The Darwinulocopina differ from the Cypridocopina in having a unique AMAS, in absence of furcae and furcal attachments, in having a posterior process, and in lacking a wide calcified inner lamella on the infold.

Living darwinulids differ from living Cypridocopina in having pediform antennules and antennas without swimming setae (Sohn 1987:154, text fig. 1, pl. 1, figs. 2, 4, 16), in absence of furcae and furcal attachments, and in presence of a posterior process (Sohn 1987:105, fig. 1). The darwinulids differ from the Cytherocopina in having smooth instead of ornamented carapaces, in simple instead of complex hingement, in round AMAS outline, in stigmata symmetrically arranged (Sohn 1987: figs. 12, 17-19) instead of in a single vertical row.

Triebel (1941:219, fig. 48) illustrated with a photograph an AMAS of *D. stevensoni* with an accessory (frontal) scar in front and below the AMAS, and this scar was illustrated in Moore (Swain 1961:Q253, fig. 183, 2c). Sharapova (1947:215, fig. 53), illustrated with a drawing the frontal scars in *Darwinula*, and Starozhilova (in Lipatova & Starozhilova 1968:80, fig. 20a) published a drawing of two frontal scars of *Darwinula*. Frontal scars had not been recorded in other fossil and extant specimens of *D. stevensoni* until Swain (1986:pl. 4, fig. 14b) illustrated frontal scars on a Pliocene specimen from Idaho. However, I cannot explain why these scars have not been recorded in the numerous SEM micrographs of valves of living specimens of *Darwinula* (Keyser 1975; Sohn 1976, 1987).

Table 1.—Comparison of selected diagnostic morphological features among the Darwinulocopina, the Cypridocopina, and the Cytherocopina.

	Darwinulocopina	Cypridocopina	Cytherocopina
Shell			
Shape	Elongate-ovate	variable	variable
Surface	smooth or with ventroposterior spine	ornamented or smooth	ornamented or smooth
Hinge	simple	simple	complex
Overlap	narrow	wide	narrow or wide
Vestibule	absent or present	present	present
Outline of AMAS	rosette	disorganised	vertical row
Number of spots	6–12	7 or less	4 or 5
Frontal & mandibular scars	absent or present	present	present
Eye tubercle	absent	absent	present or absent
Appendages			
Antennules	pediform (Sohn 1987:pl. 2, figs. 1–6)	natatory except candonids (Moore 1961: fig. 137, 1a)	pediform
Antenna, endopodite	pediform (Sohn 1987:pl. 2, figs. 7–13)	natatory except candonids (Moore 1961: fig. 137, 2a)	pediform with flagellum
Antenna, exopodite	vestigial	vestigial	flagellum with secreting duct (Moore, 1961: fig. 137, 3a)
Posterior process	Present	absent	absent
Furcal rami	absent	present or reduced	absent
Reproduction	asexual, ?sexual	sexual, rarely asexual	sexual

*Stratigraphic range.*—Carboniferous to Holocene.

Superfamily Darwinulacea Brady and Norman, 1889

Darwinulacea Swain, 1961:Q253.

*Diagnosis.*—A superfamily in Darwinulocopina with small (less than 1 mm), elongate, relatively thin shelled, smooth carapaces; gently convex dorsal margins; simple hinges; narrow overlap, AMAS outlines round, with large stigmata.

*Family assigned.*—Darwinulidae Brady & Norman, 1889.

*Discussion.*—Only the Darwinulidae Bra-

dy & Norman, 1889 and the Microdarwinulidae Kashevarova & Neustrueva, 1982 are based on living genera; the other families listed in Sohn (1987:151, table 1) are based on fossil taxa, and their referral to the Darwinulacea is based on published data and is subject to change. Except for *Whipplella* Holland, 1934 (type species (original designation) *W. cuneiformis* Holland, 1934:344, pl. 25, fig. 5. Permian), all the fossil genera in the list are based on European and Asiatic specimens that cannot be forwarded for study in the U.S. The only exception are two topotypes of *Panxiania subelliptica* Wang, 1978, the type species of the nominate genus of the family Panxianidae Wang,

1980, that Dr. Wang donated. The genus *Vymella* Kalis & Mischina in Mischina & Kalis 1975 (type species (original designation) *V. nazarovae* Kalis & Mischina: 77, pl. 9, figs. 1, 2. Late Triassic) contains species with an infold, which bears a wide calcified lamella, that excludes that genus from the Darwinulacea.

*Stratigraphic range*.—Carboniferous to Holocene.

Family Darwinulidae Brady and Norman, 1889

Darwinulidae Brady & Norman, 1889:121.

Darwinellidae Brady, Crosskey, & Robertson, 1874:140.

Microdarwinulidae Kashevarova & Neustrueva, 1982:148.

Suchonellinae Kukhtinov, 1985:68.

*Diagnosis*.—Same as the superfamily.

*Genera assigned*.—*Darwinula* Brady & Robertson in Jones, 1885; *Microdarwinula* Danielopol, 1968; *Paradarwinula* Kozur, 1970.

*Discussion*.—Kukhtinov (1985:68) included in the Darwinulidae the genera *Darwinula* (*Darwinula*), *Gerdalia* Belousova, 1961, and *Paradarwinula* Kozur, 1970, which he raised to generic rank, and he described the subfamily Suchonellinae in the family. Based on the illustrated darwinulid AMAS in the type species, *D. (P.) spinosa* (Kozur, 1970, fig. 1). *Paradarwinula* is confirmed in the Darwinulidae. Based on the original description, *Microdarwinula* does not require a separate suprageneric category. *Suchonellina* is considered herein to be a synonym of *Darwinula*, and, consequently, does not require a suprageneric category.

*Stratigraphic range*.—Carboniferous to Holocene.

Genus *Darwinula* Brady and Robertson in Jones, 1885

*Darwinula* Brady & Robertson in Jones, 1885: 346.

*Polycheles* Brady & Robertson, 1870:25.

*Darwinella* Brady & Robertson, 1872:50.

*Suchonellina* Spizharsky, 1937:156.

?*Cyprione* Jones, 1885: 343.

?*Gerdalia* Belousova, 1961:140.

*Darwinula* (*Neudarwinula*) Mischina, 1972: 49, 50.

*Type species* (monotypy).—*Polycheles stevensoni* Brady & Robertson, 1870:25.

*Diagnosis*.—Small, less than 1 mm in length, elongate, smooth darwinulids, with adont hinge, dorsal edge of one valve inserts into groove of other and ventral edge of groove of latter fits into groove of former valve, slight overlap of one valve over other along free margins. Apparently parthenogenetic; may or may not retain the eggs and brood the first two instars.

*Discussion*.—Reversal of overlap in *Darwinula* and the above synonyms has been recorded (Sohn & Chatterje 1979:584). Belousova described *Gerdalia* (type species (original designation) *Gerdalia polenovae* Belousova, 1961:141, pl. 1, figs. 1, 1a) from carapaces. Starozhilova (in Lipatova & Starozhilova, 1968:91) included species having a reversed overlap. Sharapova (1947:215) published a drawing showing the hinge of *Darwinula* having a ridge in the right valve that fits into a groove in the left valve. This hingement differs from the hinge of *Darwinula* illustrated by Sohn (1987: pl. 1) which has grooves in both valves. Sharapova's illustration of the hinge was published by Starozhilova (in Lipatova & Starozhilova 1968:80, fig. 20; 91, fig. 26; 97, fig. 31) for *Darwinula*, *Gerdalia*, and *Suchonellina* (type species (subsequent designation) *S. inornata* (McCoy, 1844) sensu Spizharsky 1939:194, pl. 46, fig. 7).

Mischina (1972) did not formally describe the subgenus *Neudarwinula*; she based her subgenus on measurements of *Darwinula parallela* (Spizharsky) without documentation. *Darwinula parallela* (Spizharsky) in Schneider 1948:24, pl. 1, figs. 5a, b, was a manuscript name of a Permian species described as *Suchonellina* Spizharsky, 1937 that was validated by Schneider (1948:24, pl. 1, figs. 5a, b). Kashevarova and Neustrueva (1982:143, 145) considered the sub-

genus *Darwinula* (*Neudarwinula*) to be a junior synonym of *Suchonellina*.

Although a male copulatory appendage was illustrated by Brady and Robertson in the original description of the type species (1870:pl. 10, fig. 13), and the antennule and the tip of the second foot of a male *D. improvisa* Turner, 1895 were illustrated (Turner 1895:263, pl. 81, figs. 1, 2), there are no other published records of males in *Darwinula* (Sohn, 1987:152). The presence of males in *Darwinula* and its suprageneric categories is considered dubious until such time that males are documented based on living material.

Jaanusson (1985:79–81) differentiated between the brood care of eggs in the platycopids and the podocopids. He named the platycopid egg care “*Cytherella* type,” and the podocopid egg care, including *Darwinula*, “*Cyprideis* type.” In *Cytherella abyssorum* Sars, 1865 the eggs are attached firmly to the inner epithelial layer inside the posterior part of the carapace where each egg leaves an impression in the inside of the valve; in the *Cyprideis* type the extruded eggs in the posterior part of the carapace are not attached and are freely movable. According to Jaanusson there is no evidence that *Cytherella* does or does not retain the early instars within the carapace. *Darwinula* retains the first two instars within the carapace where they can be observed with transmitted light or by video tape recordings opening their valves and/or extruding their appendages.

*Ecology*.—Mainly freshwater, rare in brackish water (salinity to 13‰ according to Keyser 1975:266), terrestrial (damp moss), and phreatic.

*Geographic distribution*.—Circumglobal.

*Geologic range*.—Mississippian to Holocene.

Genus *Microdarwinula* Danielopol, 1968

*Microdarwinula* Danielopol, 1968:154.

*Type species* (original designation).—(*Darwinula zimmeri* Menzel, 1916:487, figs.

16–21, and redescribed and reillustrated by Danielopol, 1968:figs. 1–28.

*Diagnosis*.—Differs from *Darwinula* in having smooth tripartite hinge that consists of terminal elongate smooth bars and smooth central groove in right valve and opposing structures in larger left valve; in having internal tubercles at both ends of ventral margins of left valve; and in not brooding the young.

*Discussion*.—Danielopol described, discussed and illustrated in detail females of the type species, but did not mention males.

*Ecology*.—Freshwater.

*Geographic distribution*.—Africa, Madagascar, and Europe.

*Geologic range*.—Oligocene to Holocene.

Genus *Paradarwinula* Kozur, 1970

*Darwinula* (*Paradarwinula*) Kozur, 1970:434.

*Type species* (original designation).—*Darwinula dreyeri* Kozur, 1968:848, pl. 4, fig. 10.

*Diagnosis*.—Differs from *Darwinula* and *Microdarwinula* in having ventroposterior spine on left valve.

*Discussion*.—Based on the illustration of the AMAS by Kozur (1970:435, fig. 10) the genus belongs in the Darwinulidae. Because Kozur (1968; 1970) did not describe the inside of the valves, the inside morphology is unknown.

*Ecology*.—Brackish water.

*Geographic distribution*.—Europe.

*Geologic range*.—Late Triassic.

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